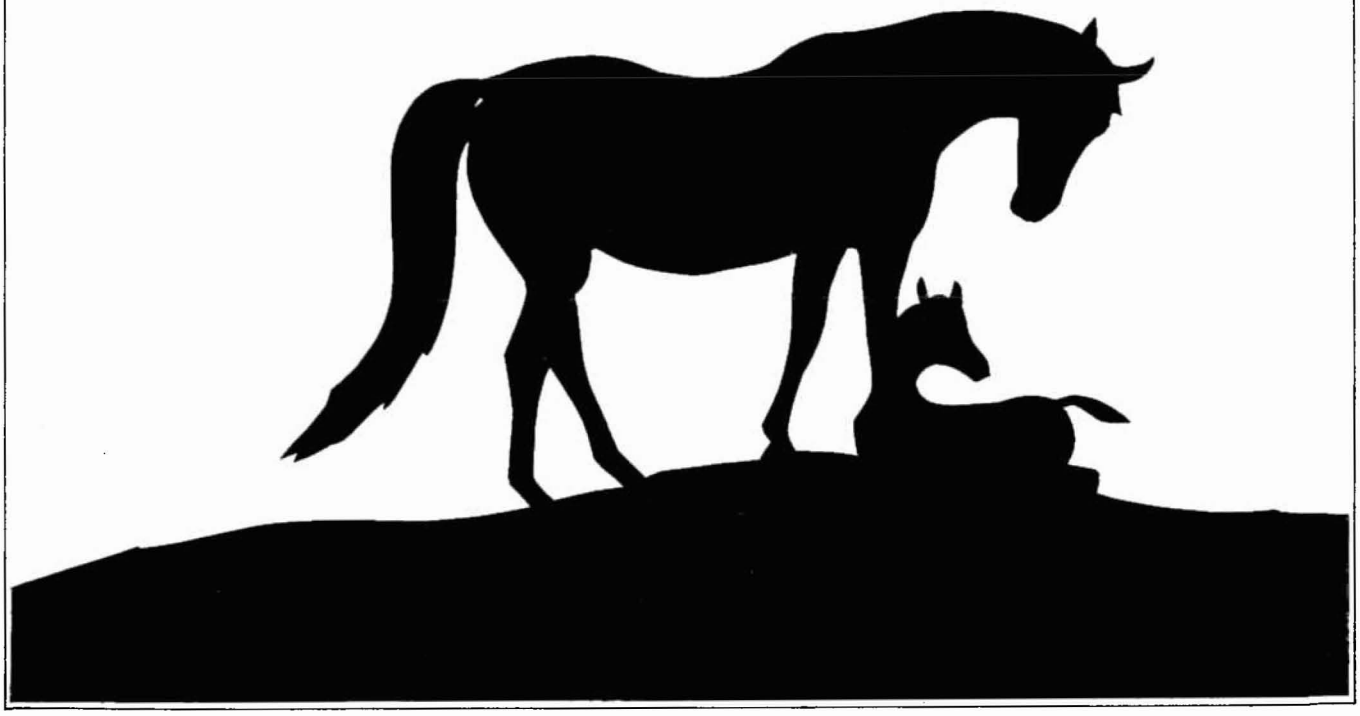
Cooperative Extension Service · College of Tropical Agriculture and Human Resources · University of Hawaii
CIRCULAR 498

HORSE NUTRITION

Coy C. Brooks and Charles M. Campbell



THE AUTHORS

Coy C. Brooks is Director of the Tidewater Research and Continuing Education Center, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University.

Charles M. Campbell is Animal Scientist, Beaumont Research Center, Department of Animal Science, College of Tropical Agriculture and Human Resources, University of Hawaii.

Library of Congress Cataloging in Publication Data

Brooks, Coy Clifton, 1918
Horse nutrition.

(Circular ; 498)
1. Horses--Feeding and feeds. I. Campbell, Charles M. II. Title. III. Series: Circular (Hawaii Institute of Tropical Agriculture and Human Resources) ; 498.
SF285.5.B76 636.1'084 81-13278
AACR2

CONTENTS

Tables

Appendix Tables

Illustrations

HORSE NUTRITION

C. C. Brooks and C. M. Campbell

INTRODUCTION

Obtaining optimum performance from the horse requires that feeds be selected and combined to supply nutrients at recommended levels and ratios. Feed materials should be chosen for nutrient content and availability. The type and amount of nutrients needed vary with the activity of the animal, while availability of nutrients varies with the type of vegetation and with the condition, growth, and maturity of the plant.

The horse is classified as a nonruminant (having a single-compartment stomach) animal, but it has a larger cecum and colon than most other simple-stomach animals—such as pig, dog, or man—which allows it to utilize more roughage in its diet. The nonruminant system of fermenting feeds in the lower tract is less efficient than the ruminant (animals with four-compartment stomachs) system at breaking down cellulose or fiber.

The makeup and capacity of the horse digestive tract lie between those of ruminants and other nonruminants. (This is illustrated in Figures 1, 2, and 3.) The same is true of the nutrient requirements for maintenance of the horse.

BASIC NUTRITIONAL REQUIREMENTS

For top performance, the horse requires a combination of feedstuffs that give a balance of energy, protein, minerals, and vitamins. The following sections will discuss each of these needs individually.

Energy Feeds

The adult working horse must have feedstuffs that supply the large amounts of energy expended. Feed grains such as oats, corn, milo, or barley can serve as concentrated sources of energy. It is important, however, to feed grains by weight rather than volume, and to control the ratio of grain to roughage in order to prevent digestive problems due to insufficient bulk in the total ration.

Energy from feeds can be expressed as TDN—total digestible nutrients: TDN = digestible carbohydrates + digestible protein + (2.25 × digestible fat). Dry roughages vary from 40 to 55 percent TDN, while concentrates range from 60 to 80 percent TDN. Energy may also be expressed as digestible energy (DE). One pound of TDN equals 2004 Kcal DE, or 1 kg TDN = 4410 Kcal DE.

Energy comes primarily from carbohydrates and lipids, which are discussed next. (Protein, which is also an energy source, is not generally used primarily for energy because of its higher cost. It is discussed later as a tissue builder.)

Carbohydrates. Carbohydrates are compounds made from simple sugars and include sugar, starch, hemicellulose, and cellulose. Most soluble carbohydrates (sugars and starches) are broken down and absorbed in the stomach and small intestine. The more fibrous carbohydrates (hemicellulose and cellulose) require bacterial action before the sugar becomes available for use. Concentrates (grains) are high in readily available starch and sugar, while roughages contain more

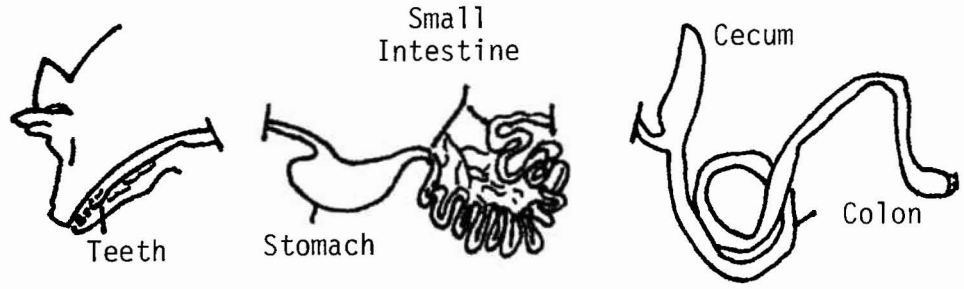


Figure 1. Digestive system of a hog (400 lb). Teeth (44): 6 incisors, upper and lower; 2 canines, upper and lower; 7 molars, upper and lower on each side. Capacity: stomach, 2.1 gal; small intestine, 2.4 gal; cecum, 0.3 gal; colon, 2.3 gal. Length: small intestine, 60 ft; cecum, 9 in; colon, 16.4 ft.

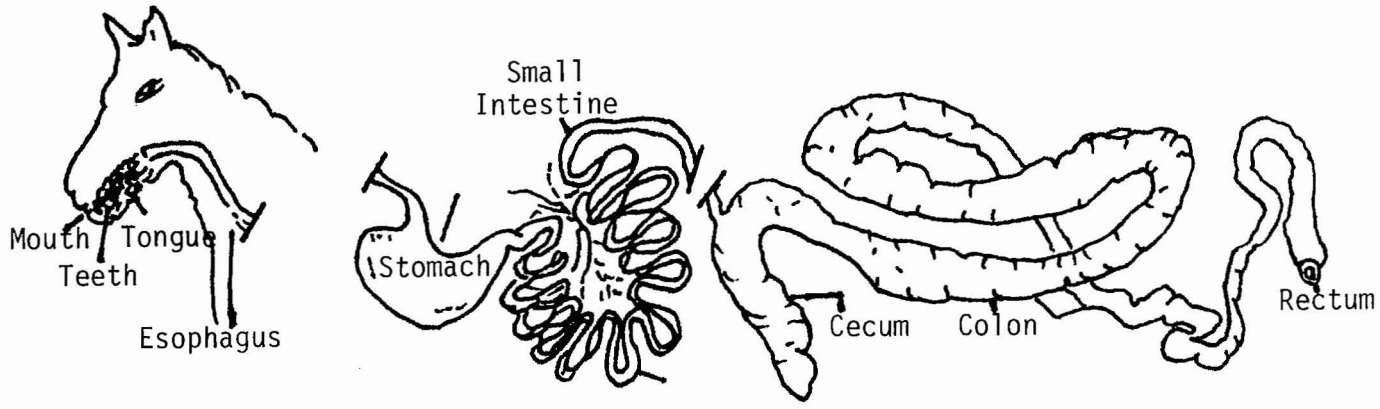


Figure 2. Digestive system of a horse (1000 lb). Teeth (40 male, 36 female): 6 incisors, upper and lower; 1 canine (male only), upper and lower on each side; 6 molars, upper and lower on each side. Capacity: stomach, 2.1 gal; small intestine, 7 gal; cecum, 3.7 gal; colon, 10.8 gal. Length: small intestine, 70 ft; cecum, 40 in; colon, 20 ft.

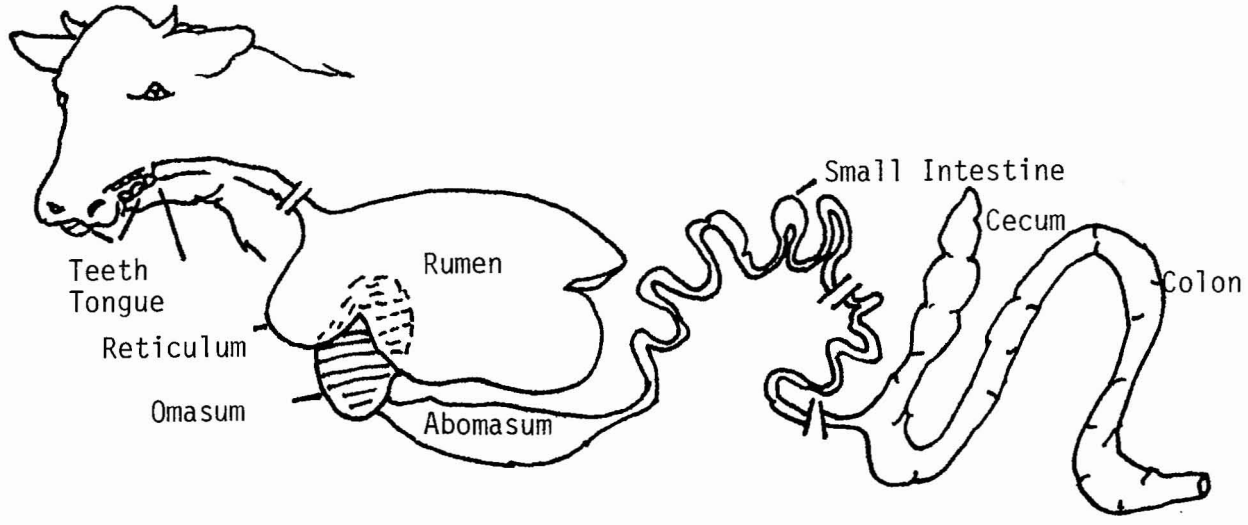


Figure 3. Digestive system of a cow (1000 lb). Teeth (32): 8 incisors, lower only; 6 molars, upper and lower on each side. Capacity: rumen and reticulum, 33 gal; omasum, 5.3 gal; abomasum, 4 gal; small intestine, 17 gal; cecum, 2.6 gal; colon, 6.6 gal. Length: small intestine, 150 ft; cecum, 2.9 ft; colon, 33 ft.

fiber (hemicellulose and cellulose), which is more difficult to digest because of the need for bacterial fermentation.

Lipids. Simple lipids include fats, oils, and waxes. Combinations of simple lipids and other substances are called compound lipids. Simple lipids such as fats and oils are generally readily available to the animal and are concentrated energy sources. They supply about 2.25 times as much energy as carbohydrates or proteins. Fat is absorbed primarily from the small intestine. Although the horse does not have a gall bladder, it is able to digest fat quite efficiently. In fact, mature horses are known to tolerate up to 18 percent fat in the diet.

The total feed—roughage and concentrate combined—should not contain more than 63 percent TDN unless the horse has been very slowly accustomed to it. The horse's capacity, desired size of middle (girth), and total energy requirement determine the proper energy and nutrient concentration of the feed. Idle horses may get adequate amounts of energy from good-quality roughage alone provided there is no objection to the size of middle that may result.

Proteins

Proteins are the source of amino acids, which are the building components for active body tissue such as muscle, organs, and blood. Some amino acids are termed essential, meaning they cannot be formed by the horse from other amino acids. The degree to which a feed supplies needed levels and balance of essential amino acids determines its protein quality.

From 60 to 70 percent of the protein is absorbed as amino acids by the small intestine. Although some fermentation of protein and other nitrogen sources occurs in the large intestine, and some bacterial protein is formed, the breakdown of these proteins and their absorption as amino acids from this area are still questionable. It is clear, however, that the essential amino acid content and ratio (protein quality) of the diet is important, particularly for young, growing horses and lactating mares.

The protein requirement for maintenance is low. The amount needed for work beyond maintenance requirements is too small to measure. Growth, reproduction, and lactation demands are quite high, however. Protein requirements of the horse, therefore, are highly variable. Satisfactory protein supplements include legume hays and oil meals. Protein in hays is generally about 60 percent digestible, while protein in concentrate is amost 76 percent digestible.

Minerals

Salt requirements of the horse vary greatly, primarily depending on the amount of perspiration. On a hot day, 60 g salt or more may be lost in the sweat and 35 g in the urine by a horse at moderate work. Salt can be provided free-choice in a salt box protected from water and dirt as long as the horse is accustomed to eating salt and is not allowed to become salt-starved. Feeding loose salt with grains will insure adequate salt intake. A horse forced to lick a salt block for all his salt need may develop a sore tongue. If there is a possibility of the horse's being salt-hungry, start out by limiting salt intake.

Calcium and phosphorus are required for healthy bones and teeth plus many body functions. These minerals must be fed in adequate amounts and in the proper ratio. Excessive feeding of either should be avoided. Horses fed high-roughage rations are likely to need phosphorus supplements, while high-concentrate rations are apt to be deficient in calcium. Dietary calcium and phosphorus needs of the horse and the feed composition should be checked when determining which supplements are to be fed. Nutrient requirements are given in the tables on pp. 7-12.

Plants, including forages grown in soils with a high level of available phosphorus (such as marshy soils), sometimes contain very high levels of phosphorus relative to calcium. Rice bran is a concentrate with a very high phosphorus level. It is on such feeds that the disease known as "big head" (secondary hyperparathyroidism) is common among horses. In this case, dietary calcium should be maintained at a slightly higher level than phosphorus. Adequate dietary vitamin D and copper levels are also essential to proper calcium and phosphorus nutrition. High calcium and phytic acid (associated with high plant phosphorus) may increase the zinc as well as the copper requirement. It is important that adequate zinc, copper, and calcium are available when the horse receives feeds high in phosphorus.

Other minerals are required in trace quantities, and amounts vary considerably among feeds.

These include iodine, iron, copper, manganese, zinc, and magnesium, all of which may be supplied by feeding trace-mineralized salt. In hot weather, however, the hardworking horse should not be fed trace-mineral salt as the only salt source. Other minerals are required, although they are not likely to be lacking under normal feeding conditions.

The mineral needs of the horse on pasture or high-roughage rations can generally be provided by offering a free choice of loose salt in one compartment of a mineral feeder, and in the other compartment a mixture of 50 percent bone meal or dicalcium phosphate, 25 percent limestone, and 25 percent trace-mineral salt containing iodine, copper, zinc, magnesium, and cobalt. The mineral and salt should be kept dry and fresh. For added safety, check the calcium and phosphorus level of the diet against the horse's need, and from this determine whether the ratio of calcium to phosphorus in the mineral mix should be changed.

Vitamins

Vitamin A is necessary for the normal functioning of many biological systems including the nervous, digestive, reproductive, and skeletal systems. Another important function of vitamin A is its role in overcoming the effects of stress. Vigorous training, for example, may increase a horse's need for vitamin A. Vitamin A may be supplied by its precursor, carotene. For horses 1 mg of carotene is assumed to equal 400 IU of vitamin A. Green forages generally have high quantities of carotene. It may be lost, however, as the plants mature. It also may be lost from harvested plants by bleaching, leaching, or oxidation resulting from heat or prolonged storage. Vitamin A also may be supplied by a feed supplement. The supplement, as well as the vitamin A from carotene, may be stored in the animal's body, providing a buffer against short-term deficiency. Nevertheless, it is sound practice to assure that some vitamin A source is available to the horse at all times.

Vitamin D supply is usually adequate from sun-cured hay or from exposure of the animal to sunlight. The exact need for other fat-soluble vitamins (E and K) is not clear. They are probably in adequate supply in most normal diets. Vitamin E is important in some areas to prevent white muscle disease in foals, and it appears to help overcome the symptoms of the tying up syndrome in horses.

The water-soluble B vitamins are all produced in fermentation. Thiamine (B_1), riboflavin, niacin, pantothenic acid, B_{12}, and choline are produced in the cecum of the horse. Supply is probably adequate when horses are fed diets containing good-quality forage or a balanced grain mix. When horses are under the stress of heavy training, however, or when poor-quality feeds are used, additional thiamine, riboflavin, niacin, and pantothenic acid should be provided. There is evidence that thiamine and riboflavin supplements may be needed if good-quality feeds are not given to horses doing even light work, to growing colts, or to lactating mares. Choline at high levels (6 to 8 g daily) has been recommended to relieve heaves, and B_{12} for poor appetite, weakness, and anemia. The therapeutic value of these vitamins, however, has not been established by research. If there is doubt about the B-vitamin adequacy of a diet and a satisfactory vitamin mix designed for horses is not available, then a vitamin pre-mix designed for growing swine, added to the total feed at half the level recommended for swine, should insure an adequate vitamin supply.

The nutrient requirements of horses by weight and activity are given in Tables 1A, 1B, 1C, 1D, 2A, 2B, and 3. Daily feed requirements in these tables are based on a 63-percent TDN ration. If the horse has the capacity to eat more, a lower-TDN feed may be used. In this situation, a lower concentration of the other nutrients is needed. Conversely, if the horse's middle is to be drawn (as in high conditioning) by increasing feed concentration above 63 percent TDN, then less feed and a greater concentration of nutrients is needed. For these reasons nutritional requirements are given both as percentages in the feed and as total amount needed daily by the animal. The daily requirement is to be used in calculating rations in which the TDN is greater or less than 63 percent.

FEEDS FOR HORSES

Grains or Basal Energy Feeds

Oats are the most widely used grain for horses. Heavy, bright oats containing a small percentage of hull are preferred because of their high palatability and general freedom from factors causing digestive upset. Musty oats should never be used as they may cause colic. It is best to roll or crush the oats for horses with poor teeth or for young foals.

Table 1A. Nutrient requirements of horses (daily nutrients per horse), ponies, 200 kg (440 lb) mature weight.

	Weight		Daily gain		Digestible energy	TDN		Crude protein		Digestible protein		Cal-cium	Phos-phorus	Vitamin A activity	Daily feed[a]	
	kg	lb	kg	lb	(Mcal)	kg	lb	kg	lb	kg	lb	(g)	(g)	(1000 IU)	kg	lb
Mature ponies, maintenance	200	440	0.0		8.24	1.87	4.12	0.32	0.70	0.14	0.31	9	6	5.0	3.75	8.2
light work[b]					10.44	2.4	5.3	0.38	0.80							
medium work[b]					13.16	3.0	6.6	0.48	1.10							
Mares, last 90 days gestation			0.27	0.594	9.23	2.10	4.62	0.39	0.86	0.20	0.41	14	9	10.0	3.70	8.1
Lactating mare, first 3 months (8 kg milk per day)			0.0		14.58	3.31	7.29	0.71	1.56	0.54	1.19	24	16	13.0	5.20	11.5
Lactating mare, 3 months to weanling (6 kg milk per day)			0.0		12.99	2.95	6.50	0.60	1.32	0.34	0.75	20	13	11.0	5.00	11.0
Nursing foal (3 months of age)	60	132	0.70	1.54	7.35	1.67	3.68	0.41	0.90	0.38	0.84	18	11	2.4	2.25	5.0
Requirements above milk					3.74	0.85	1.87	0.17	0.37	0.20	0.44	10	7	0.0	1.20	2.7
Weanling (6 months of age)	95	209	0.50	1.10	8.80	2.0	4.40	0.47	1.03	0.31	0.68	19	14	3.8	2.85	6.3
Yearling (12 months of age)	140	308	0.20	0.44	8.15	1.85	4.07	0.35	0.77	0.20	0.44	12	9	5.5	2.90	6.4
Long yearling (18 months of age)	170	374	0.10	0.22	8.10	1.84	4.05	0.32	0.70	0.17	0.37	11	7	6.0	3.10	6.8
Two-year-old (24 months of age)	185	407	0.05	0.11	8.10	1.84	4.05	0.30	0.66	0.15	0.33	10	7	5.5	3.10	6.8

[a] Dry matter basis.

[b] Not included in the NAS table. Work does not increase measurably the need for digestible protein, calcium, phosphorus, vitamin A, or daily feed.

Reproduced from "Nutrient Requirements of Horses," 1978, with the permission of the National Academy of Sciences, Washington, D.C.

Table 1B. Nutrient requirements of horses (daily nutrients per horse), 400 kg (880 lb) mature weight.

	Weight		Daily gain		Digestible energy	TDN		Crude protein		Digestible protein		Cal-cium	Phos-phorus	Vitamin A activity	Daily feed[a]	
	kg	lb	kg	lb	(Mcal)	kg	lb	kg	lb	kg	lb	(g)	(g)	(1000 IU)	kg	lb
Mature horses, maintenance	400	880	0.0		13.86	3.15	6.93	0.54	1.19	0.24	0.53	18	11	10.0	6.30	13.9
light work[b]					18.36	4.2	9.3	.67	1.5			19	11			
medium work[b]					23.80	5.5	12.2	.88	1.9			20	11			
Mares, last 90 days gestation			0.53	1.17	15.52	3.53	7.76	0.64	1.41	0.34	0.75	27	19	20.0	6.20	13.7
Lactating mare, first 3 months (12 kg milk per day)			0.0		23.36	5.31	11.68	1.12	2.46	0.68	1.50	40	27	22.0	8.35	18.4
Lactating mare, 3 months to weanling (8 kg milk per day)			0.0		20.20	4.59	10.10	0.91	2.00	0.51	1.12	33	22	18.0	7.75	17.1
Nursing foal (3 months of age)	125	275	1.00	2.2	11.51	2.62	5.76	0.65	1.43	0.50	1.10	27	17	5.0	3.55	7.8
Requirements above milk					6.10	1.39	3.05	0.40	0.88	0.30	0.66	15	12	0.0	1.95	4.3
Weanling (6 months of age)	185	407	0.65	1.43	13.03	2.96	6.51	0.66	1.45	0.43	0.95	27	20	7.4	4.20	9.2
Yearling (12 months of age)	265	583	0.40	0.88	13.80	3.14	6.91	0.60	1.32	0.35	0.77	24	17	10.0	4.95	10.9
Long yearling (18 months of age)	330	726	0.25	0.55	14.36	3.26	7.17	0.59	1.30	0.32	0.70	22	15	11.5	5.50	12.2
Two-year-old (24 months of age)	365	803	0.10	0.22	13.89	3.16	6.95	0.52	1.14	0.27	0.59	20	13	11.0	5.35	11.8

[a] Dry matter basis.

[b] Not included in the NAS table. Work does not increase measurably the need for digestible protein, vitamin A, or daily feed.

Reproduced from "Nutrient Requirements of Horses," 1978, with the permission of the National Academy of Sciences, Washington, D.C.

Table 1C. Nutrient requirements of horses (daily nutrients per horse), 500 kg (1100 lb) mature weight.

	Weight		Daily gain		Digestible energy	TDN		Crude protein		Digestible protein		Cal-cium	Phos-phorus	Vitamin A activity	Daily feed[a]	
	kg	lb	kg	lb	(Mcal)	kg	lb	kg	lb	kg	lb	(g)	(g)	(1000 IU)	kg	lb
Mature horses, maintenance	500	1,100	0.0		16.39	3.73	8.20	0.63	1.39	0.29	0.64	23	14	12.5	7.45	16.4
light work[b]					21.89	5.00	11.00	.8	1.8						8.00	17.6
medium work[b]					28.69	6.60	14.60	1.0	2.3						10.45	23.0
Mares, last 90 days gestation			0.55	1.21	18.36	4.17	9.18	0.75	1.65	0.39	0.86	34	23	25.0	7.35	16.2
Lactating mare, first 3 months (15 kg milk per day)			0.0		28.27	6.43	14.14	1.36	2.99	0.84	1.85	50	34	27.5	10.10	22.2
Lactating mare, 3 months to weanling (10 kg milk per day)			0.0		24.31	5.53	12.16	1.10	2.42	0.62	1.36	41	27	22.5	9.35	20.6
Nursing foal (3 months of age)	155	341	1.20	2.64	13.66	3.10	6.83	0.75	1.65	0.54	1.19	33	20	6.2	4.20	9.2
Requirements above milk					6.89	1.57	3.45	0.41	0.90	0.31	0.68	18	13	0.0	2.25	4.9
Weanling (6 months of age)	230	506	0.80	1.76	15.60	3.55	7.80	0.79	1.74	0.52	1.14	34	25	9.2	5.00	11.0
Yearling (12 months of age)	325	715	0.55	1.21	16.81	3.82	8.41	0.76	1.67	0.45	0.99	31	22	12.0	6.00	13.2
Long yearling (18 months of age)	400	880	0.35	0.77	17.00	3.90	8.58	0.71	1.56	0.39	0.86	28	19	14.0	6.50	14.3
Two-year-old (24 months of age)	450	990	0.15	0.33	16.45	3.74	8.23	0.63	1.39	0.33	0.72	25	17	13.0	6.60	14.5

[a] Dry matter basis.

[b] Not included in the NAS table. Work does not increase measurably the need for digestible protein, calcium, phosphorus, or vitamin A.

Reproduced from "Nutrient Requirements of Horses," 1978, with the permission of the National Academy of Sciences, Washington, D.C.

Table 1D. Nutrient requirements of horses (daily nutrients per horse), 600 kg (1320 lb) mature weight.

	Weight		Daily gain		Digestible energy	TDN		Crude protein		Digestible protein		Calcium	Phosphorus	Vitamin A activity	Daily feed[a]	
	kg	lb	kg	lb	(Mcal)	kg	lb	kg	lb	kg	lb	(g)	(g)	(1000 IU)	kg	lb
Mature horses, maintenance	600	1,320	0.0		18.79	4.27	9.40	0.73	1.61	0.33	0.73	27	17	15.0	8.50	18.8
Mares, last 90 days gestation			0.67	1.47	21.04	4.78	10.52	0.87	1.91	0.46	1.01	40	27	30.0	8.40	18.5
Lactating mare, first 3 months (18 kg milk per day)			0.0		33.05	7.51	16.53	1.60	3.52	0.99	2.18	60	40	33.0	11.80	26.0
Lactating mare, 3 months to weanling (12 kg milk per day)			0.0		28.29	6.43	14.15	1.29	2.84	0.73	1.61	49	30	27.0	10.90	23.9
Nursing foal (3 months of age)	170	374	1.40	3.08	15.05	3.42	7.53	0.84	1.85	0.78	1.72	36	23	6.8	4.65	10.2
Requirements above milk					6.93	1.58	3.47	0.51	1.12	0.38	0.84	18	15	0.0	2.25	4.9
Weanling (6 months of age)	265	583	0.85	1.87	16.92	3.85	8.47	0.86	1.89	0.57	1.25	37	27	10.6	5.45	12.0
Yearling (12 months of age)	385	847	0.60	1.32	18.85	4.28	9.42	0.90	1.98	0.50	1.10	35	25	14.0	6.75	14.8
Long yearling (18 months of age)	475	1,045	0.35	0.77	19.06	4.33	9.53	0.75	1.65	0.43	0.95	32	22	13.5	7.35	16.2
Two-year-old (24 months of age)	540	1,188	0.20	0.44	19.26	4.38	9.64	0.74	1.63	0.39	0.86	31	20	13.0	7.40	16.3

[a] Dry matter basis.

Reproduced from "Nutrient Requirements of Horses," 1978, with the permission of the National Academy of Sciences, Washington, D. C.

Table 2A. Nutrient concentrations in diets for horses and ponies expressed on 100 percent dry matter basis.[a]

	Digestible energy		Example diet proportions: Hay containing 2.2 Mcal/kg		Hay containing 2.0 Mcal/kg		Crude protein (%)	Calcium (%)	Phosphorus (%)	Vitamin A activity	
	Mcal/kg	Mcal/lb	Concentrate[b]	Roughage	Concentrate[b]	Roughage				IU/kg	IU/lb
Mature horses and ponies at maintenance	2.2	1.0	0	100	10	95	8.5	0.30	0.20	1,600	725
Mares, last 90 days of gestation	2.5	1.1	25	75	35	65	11.0	0.50	0.35	3,400	1,550
Lactating mare, first 3 months	2.8	1.3	45	55	55	45	14.0	0.50	0.35	2,800	1,275
Lactating mare, 3 months to weanling	2.6	1.2	30	70	40	60	12.0	0.45	0.30	2,450	1,150
Creep feed	3.5	1.6	100	0	100	0	18.0	0.85	0.60		
Foal (3 months of age)	3.25	1.5	75	25	80	20	18.0	0.85	0.60	2,000	900
Weanling (6 months of age)	3.1	1.4	65	35	70	30	16.0	0.70	0.50	2,000	900
Yearling (12 months of age)	2.8	1.3	45	55	55	45	13.5	0.55	0.40	2,000	900
Long yearling (18 months of age)	2.6	1.2	30	70	40	60	11.0	0.45	0.35	2,000	900
Two-year-old (light training)	2.6	1.3	30	70	40	60	10.0	0.45	0.35	2,000	900
Mature working horses											
light work[c]	2.5	1.1	25	75	35	65	8.5	0.30	0.20	1,600	725
moderate work[d]	2.9	1.3	50	50	60	40	8.5	0.30	0.20	1,600	725
intense work[e]	3.1	1.4	65	35	70	30	8.5	0.30	0.20	1,600	725

[a] Values are rounded to account for differences among Tables 1A–1D and for greater practical application.
[b] Concentrate containing 3.6 Mcal/kg.
[c] Examples are horses used in western pleasure, bridle path hack, equitation, etc.
[d] Examples are ranch work, roping, cutting, barrel racing, jumping, etc.
[e] Examples are race training, polo, etc.
Reproduced from "Nutrient Requirements of Horses," 1978, with the permission of the National Academy of Sciences, Washington, D.C.

Table 2B. Nutrient concentration in diets for horses and ponies expressed on 90 percent dry matter basis.[a]

	Digestible energy		Crude protein	Calcium	Phosphorus	Vitamin A activity	
	Mcal/kg	Mcal/lb	(%)	(%)	(%)	IU/kg	IU/lb
Mature horses and ponies at maintenance	2.0	0.9	7.7	0.27	0.18	1,450	650
Mares, last 90 days of gestation	2.25	1.0	10.0	0.45	0.30	3,000	1,400
Lactating mare, first 3 months	2.6	1.2	12.5	0.45	0.30	2,500	1,150
Lactating mare, 3 months to weanling	2.3	1.1	11.0	0.40	0.25	2,200	1,000
Creep feed	3.15	1.4	16.0	0.80	0.55		
Foal (3 months of age)	2.9	1.35	16.0	0.80	0.55	1,800	800
Weanling (6 months of age)	2.8	1.25	14.5	0.60	0.45	1,800	800
Yearling (12 months of age)	2.6	1.2	12.0	0.50	0.35	1,800	800
Long yearling (18 months of age)	2.3	1.1	10.0	0.40	0.30	1,800	800
Two-year-old (light training)	2.6	1.2	9.0	0.40	0.30	1,800	800
Mature working horses							
light work[b]	2.25	1.0	7.7	0.27	0.18	1,450	650
moderate work[c]	2.6	1.2	7.7	0.27	0.18	1,450	650
intense work[d]	2.8	1.25	7.7	0.27	0.18	1,450	650

[a] Values are rounded to account for differences among Tables 1A–1D and for greater practical application.
[b] Examples are horses used in western pleasure, bridle path hack, equitation, etc.
[c] Examples are ranch work, roping, cutting, barrel racing, jumping, etc.
[d] Examples are race training, polo, etc.
Reproduced from "Nutrient Requirements of Horses," 1978, with the permission of the National Academy of Sciences, Washington, D.C.

Table 3. Dietary minerals and vitamins for horses.

	Adequate levels		
	Maintenance of mature horses	Growth	Toxic levels[a]
Calcium	—[b]	—[b]	
Phosphorus	—[b]	—[b]	
Sodium, %	0.35	0.35	
Potassium, %	0.4	0.5	
Magnesium, %	0.09	0.1	
Sulfur, %	0.15	0.15	
Iron, mg/kg	40	50	
Zinc, mg/kg	40	40	9,000
Manganese, mg/kg	40	40	*
Copper, mg/kg	9	9	*
Iodine, mg/kg	0.1	0.1	4.8
Cobalt, mg/kg	0.1	0.1	
Selenium, mg/kg	0.1	0.1	5.0
Fluorine, mg/kg	—	—	50+
Lead, mg/kg	—	—	80
Vitamin A	—[b]	—[b]	*
Vitamin D, IU/kg	275	275	150,000
Vitamin E, mg/kg	15	15	
Thiamine, mg/kg	3	3	
Riboflavin, mg/kg	2.2	2.2	
Pantothenic acid, mg/kg	15	15	

[a] Nutrients known to be toxic to other species but without adequate information on the horse are indicated by *.
[b] See Tables 1A–1D.
Reproduced from "Nutrient Requirements of Horses," 1978, with the permission of the National Academy of Sciences, Washington, D.C.

Corn is also widely used. It should be cracked, coarsely ground, or, preferably, rolled. Many horsemen provide corn during cool weather and remove it, or decrease the amount, during warm weather. This is not essential, however, since the heat increment (the increased body heat directly attributable to eating a feed) of corn is not high. Most horsemen prefer to mix corn with oats. Because of its high energy content, corn is more likely to cause digestive upset than are oats or a mixture of corn and oats.

Barley is used by some horsemen in the United States but is more popular in other countries. Since barley is hard it should be coarsely ground or, preferably, rolled. Most horsemen prefer to mix barley with oats in about equal parts. Like corn, barley can be used at high levels if care is taken to avoid overeating or quick changes in feeding regimen.

Milo (sorghum) may be used satisfactorily in horse rations. This grain is an excellent source of energy, but it must be either coarsely ground or steamed and rolled. The addition of molasses at 5 to 10 percent of the mixture will help reduce the "fines" from the ground or rolled grain. Many horsemen prefer to have their grains steam-rolled instead of ground. This reduces dust and gives a lighter ration, which should result in fewer digestive disturbances.

Wheat is not used very much for horses. When ground, it is rather doughy and tends to ball up with moisture. If used, it should be rolled and mixed at a low level with a bulky feed such as oats or wheat bran.

Wheat bran is valuable for its mild laxative effect and for its bulky nature. It is an excellent feed for starting horses, especially colts, on feed. It is generally used at levels of 5 to 15 percent of the ration.

Protein Supplements

Linseed meal is the most popular protein supplement; it produces bloom and luster in the hair coat. Some horsemen prefer pelleted linseed meal. Linseed protein, like most plant sources other than soybean, may be too low in the amino acid lysine to meet the needs of young colts or lactating mares. A mixture including soybean meal or some lysine supplement may be preferable to linseed meal alone.

Besides soybean meal, cottonseed meal, which is low in lysine, is used extensively for horses. Legume-roughage proteins are generally satisfactory in quality. Although other protein supplements are used, very little is known about their feeding value. Commercial protein supplements, which many horsemen rely upon, are generally fortified with vitamins and minerals. Some horsemen will use linseed meal or some other protein supplement, plus a commercial protein source, in about equal proportions. Protein supplements for horses should not contain urea.

Cane Molasses

When the feed contains 5 to 10 percent cane molasses it is more palatable to the horse. Sweetening feed helps to increase consumption. Some horsemen prefer to buy a commercial feed (usually called a sweet feed) that contains considerable molasses; they mix it with their own home-mixed feed to increase palatability. Molasses also reduces feed cost in Hawaii, and it cuts down on dust in the feed. Because of its laxative effect, molasses should not exceed 10 percent of the total ration of heavy-working horses.

Hay

The choice of hay depends on the horseman's preference. In some localities timothy is the preferred hay. Other horsemen, however, prefer to use legume or legume-grass hays. The important thing to remember in feeding hay to horses is that it should be free of mold and be of high quality.

Since individual horses vary in stomach capacity, it is important to experiment before determining the minimum roughage requirements of each horse. Minimum roughage needs should be determined for horses being prepared for racing or other hard work, since as much energy feed as possible must be given them. Under these conditions, just enough roughage to prevent digestive problems may be provided. Horses are often fed too much hay or pasture for maximum performance or best appearance. This causes quick tiring and labored breathing among horses that are exercised and worked heavily. It may be necessary to muzzle greedy horses to keep them from eating the bedding when their roughage allowance has to be limited.

The minimum roughage requirement of a horse is about 0.5 percent of its body weight. This means that a 1000-lb animal would require at

least 5 lb of hay or its equivalent in other roughage. Many horsemen, however, prefer to provide at least 10 lb of roughage (1.0 percent of body weight) for a 1000-lb horse. The actual amount probably varies with the energy concentration of grains used as well as the energy concentration in the roughage.

Since a distended digestive tract due to high roughage intake is a hindrance to a working horse, most horsemen prefer to feed at least half the hay allowance in the evening. The remainder is divided among the other feedings during the day. When horses are shipped to the race track, worked, or exercised heavily, most horsemen provide less hay.

In Hawaii, a horse's intake of dry matter and nutrients is limited by both the high moisture content of many green forages and the size of the horse's digestive tract. Unthrifty horses on pasture are a common occurrence. Many Hawaiian pasture forages are also deficient in minerals and protein. A supplement containing grain and either a protein concentrate or alfalfa would improve the thriftiness and performance of the pasture-fed horse in many areas of Hawaii. Mineral mix and salt should be offered as a free choice on pasture.

Pelleted Feeds

Horsemen who have tried pelleted feeds for horses have been very happy with the results, and it is reasonable to predict that these feeds will become more popular. One big advantage of pelleting feeds is the elimination of dust, which is very harmful to horses. Some horsemen have tried pelleting the whole ration, both hay and grain, and have been satisfied with the results. Pelleting has also made it possible to use dehydrated alfalfa meal for horse feeding. Five to 10 percent of pelleted, dehydrated alfalfa meal is an excellent addition to horse rations. It is a good source of vitamins, minerals, protein, and trace elements. High-quality alfalfa meal is the closest substitute for green pasture and is helpful in supplementing tropical pastures with a high water content (less than 20 percent dry matter). It is not essential, however, to successful feeding.

Pasture

Good pasture offers excellent feed as well as an exercise area for developing growing horses, maintaining idle mature horses, feeding pregnant mares, or supplying some of the requirements for lactating mares. Pasture plants, however, can quickly become too mature or low in nutrients. The pasture then becomes a starving pen if supplemental feed is not given. Unless control is used, the pasture also may be a source of internal parasites.

Pasture grass is generally too low in nutrient concentration to be used as the only feed for the working horse, the growing colt, or the lactating mare. When the horse develops the middle necessary to get the needed nutrients from either watery or high-fiber pasture, he cannot perform at his most efficient rate. He is generally sluggish from long grazing to get the feed. The practice of alternating pasture and work puts stress on the horse and allows him to lose condition and muscle tone. Such a practice usually does not save money since it requires more horses to do the same amount of work.

Table 4 presents the average composition of feeds commonly used in formulating horse rations, which is discussed next.

RATION FORMULATION

In formulating rations, one must be aware of the horse's function, its age and activity, the number of horses being fed, and the availability and relative cost of feeds. Horses should be fed according to their needs. Good feeds need not be complicated mixtures but should be high in quality, free of dust and molds, economical, and practical for local conditions. A balanced ration also has to be palatable. This means maximum use of high-quality home-grown feeds.

It is necessary to begin with a healthy horse if the intent is to improve performance through better nutrition. No amount of feed will fully overcome heavy internal parasite infestation, mange, or other causes of poor health. Major changes in the ration should be made gradually over a period of several days or a horse may go off its feed because of digestive disturbances.

In looking at the following examples, remember that mathematics is simply a tool to use in organizing a feeding program; it is no substitute for good horse sense. Close observation is necessary to make any feeding program work.

Table 4. Composition of feedstuffs on an as-fed basis.

Feed ingredient	Dry matter %	Energy TDN %	Energy DE Kcal/g	Protein (N×6.25) %	Mineral Ca %	Mineral P %	Mineral Cu mg/kg	Carotene mg/lb	Carotene mg/kg	Vitamin A[a] 1000 IU per lb	Vitamin A[a] 1000 IU per kg	Crude fiber %
Energy concentrates												
Barley	89	74	3.3	11.6	.08	.42	9	None	None	None	None	6.0
Corn, yellow, #2 dent[b]	89	81	3.6	9.0	.02	.31	3	.9	2	.4	.8	2.2
Milo (sorghum)	89	71	3.1	11.0	.04	.29	14	None	None	None	None	2.2
Molasses, cane[b]	78	61	2.8	3.5	.75	.07	50	None	None	None	None	None
Oats	89	65	2.8	11.8	.10	.35	5	None	None	None	None	11.0
Pineapple bran	86	64	—	3.8	.16	.15	—	None	None	None	None	20.0
Rice bran	91	74	2.6	13.5	.12	1.34	10	None	None	None	None	12.4
Rice polishings	90	86	3.4	11.8	.04	1.42	—	None	None	None	None	3.0
Sugar, crude	99	96	4.4	.8	.20	.03	None	None	None	None	None	None
Wheat	89	80	3.5	12.7	.05	.36	10	None	None	None	None	2.6
Wheat bran	89	58	2.3	16.0	.14	1.17	3	None	None	None	None	10.0
Wheat middling	89	73	3.3	18.0	.08	.52	4	None	None	None	None	2.0
Wheat mill run[b]	90	72	3.2	15.3	.09	1.02	4	None	None	None	None	8.0
Protein concentrates												
Coconut oil meal	90	76	3.6	20.9	.21	.61	40	None	None	None	None	10.5
Cottonseed meal	92	69	3.0	41.2	.16	1.20	19	None	None	None	None	11.7
Linseed oil meal[b]	91	69	3.0	35.1	.40	.81	28	None	None	None	None	9.0
Peanut oil meal	92	71	3.1	47.0	.22	.62	—	None	None	None	None	14.0
Soybean oil meal (44%, solvent)[b]	89	75	3.2	45.8	.32	.67	36	None	None	None	None	6.0
Soybean oil meal (50%, dehulled sol.)	90	77	3.4	50.9	.26	.62	30	None	None	None	None	2.8
Yeast, dried (Torula)	93	64	3.3	48.3	.57	1.68	33	None	None	None	None	2.9
Dry roughage												
Alfalfa (early bloom)	90	53	2.1	16.6	1.10	.20	13	18	42	7.8	17	26.8
Alfalfa (full bloom)[b]	90	48	1.9	14.3	1.10	.18	12	6	14	2.6	6	30.5
Alfalfa (mature)	90	44	1.7	12.2	.60	.15	11	5	10	1.8	4	33.8
Bermuda grass hay (coastal)	91	40	1.7	4.1	.40	.16	—	9	20	3.6	8	28.0
Napier grass hay	89	45	1.8	8.2	.30	.25	—	—	—	—	—	31.0
Orchard grass hay[b]	90	41	1.7	8.1	.41	.20	12	5	10	1.8	4	31.0
Panicum grass hay	90	51	1.9	9.6	.60	.40	—	—	—	—	—	27.0
Pangola grass hay[b]	90	48	—	7.9	.30	.17	—	—	—	—	—	29.0
Pineapple hay	86	53	—	7.8	—	—	—	—	—	—	—	25.1
Sudan hay (sorghum × sudan)	90	43	1.7	7.8	.50	.28	7	—	—	—	8	32.4
Sugarcane bagasse pith	90	41	—	1.0	.10	.04	—	—	—	—	—	37.0
Timothy hay (mid-bloom)	88	43	1.7	7.3	.33	.16	—	4	9	1.6	4	29.5
Green forage												
Bermuda grass	29	20	—	5.1	.17	.07	—	—	—	—	—	7.0
Guinea grass[b]	26	10	—	1.2	.10	.08	—	—	—	—	—	11.7
Kikuyu grass (all)	16	8	—	1.6	.04	.04	—	—	—	—	—	5.3
6 weeks regrowth[b]	15	8	—	1.9	.05	.04	—	—	—	—	—	4.7
12 weeks regrowth	14	7	—	1.3	.04	.04	—	—	—	—	—	4.9
Panicum (paragrass)	21	12	—	2.4	.04	.06	—	—	—	—	—	6.2
Pangola (all)	20	11	—	1.8	.07	.04	—	—	—	—	—	6.6
6 weeks regrowth	20	12	—	2.1	.07	.05	—	—	—	—	—	6.8
12 weeks regrowth	20	13	—	1.5	.06	.04	—	—	—	—	—	6.6
18 weeks regrowth	24	14	—	1.2	.06	.03	—	—	—	—	—	7.9
Sugarcane, fresh	27	16	—	1.3	.13	.05	—	—	—	—	—	8.0
Sugarcane, tops	23	13	—	1.4	.02	.06	—	—	—	—	—	8.5
Sugarcane, strippings	46	22	—	1.6	.04	.12	—	—	—	—	—	20.3
Calcium and phosphorus sources												
Bone meal (steamed)	95	—	—	—	20.0	12.0	—	—	—	—	—	—
Coral rock	95	—	—	—	20–30	—	—	—	—	—	—	—
Defluorinated phosphate rock	96	—	—	—	28.0	13.3	—	—	—	—	—	—
Dicalcium phosphate	95	—	—	—	27.0	19.0	—	—	—	—	—	—
Limestone	—	—	—	—	34.0	—	—	—	—	—	—	—

[a]Feeds that have been stored longer than 6 months or exposed to high heat in presence of air probably have no carotene or vitamin A.
[b]Feeds used in the ration-balancing example.

Example 1: Ration for a Mature Horse at Rest on Pasture

Assume an 1100-lb (500 kg) mature horse being maintained or rested on kikuyu (6 weeks regrowth) pasture. In formulating a ration, the following steps should be taken:

(a) Determine the nutritional needs of the horse from Table 1C.

(b) Estimate the amount of grass the horse will eat. This is difficult because of variations in pasture dry matter, quality, and palatability. The same pasture varies over time, so close observation of pasture appearance and condition of the horse is essential for continued good nutrition. A mature horse will maintain its weight on good-quality kikuyu if it eats $\frac{8.2 \text{ lb TDN need}}{.08 \text{ TDN/lb in grass}}$ = 104 lb green grass/day.

(c) Determine composition of grass from Table 2A and determine total nutrients supplied.

(d) Calculate deficiencies.

(e) Supply need by supplementation or feed substitution.

For an 1100-lb horse, the figures look like this:

	TDN	Protein	Carotene	Calcium	Phosphorus
Horse's requirement	8.2 lb	1.39 lb	31 mg	23 g	14 g
Intake from 104 lb kikuyu	8.2 lb	2.0 lb	—[a]	23 g	18g
Deficiency	none	none	none	none	none

[a] Although the carotene intake from kikuyu is not given, green pasture given free-choice should supply adequate carotene to meet the vitamin A need in addition to the B-vitamin needs.

The horse needs salt, which may be offered free-choice in a mineral box protected from the weather. When feeding this way, be sure the horse never becomes excessively salt-hungry.

Eating this amount of green, watery feed, horses develop heavy middles, loose muscle tone or condition, and poor wind. For efficient work and adequate wind, a horse should be given dry feed with a dry hay at a level not exceeding 1 percent of its body weight, or a TDN level of approximately 63 percent of the total feed.

Example 2: Ration for a Lactating Mare on Pasture

Assume an 1100-lb mare on kikuyu pasture for the first 3 months. According to Table 1C, the mare will eat 22.2 lb of air-dry feed per day. On a DM basis, this is $\frac{.90 \text{ DM/lb dry feed}}{.15 \text{ DM/lb kikuyu}}$ = 6 lb kikuyu = 1 lb dry feed, or 6 lb × 22.2 lb dry feed required = 133 lb grass.

	TDN	Protein	Calcium	Phosphorus
Mare's requirement	14.1 lb	2.99 lb	50 g	34 g
Intake from 133 lb kikuyu	10.6 lb	2.5 lb	30 g	24 g
Deficiency	3.5 lb	0.5 lb	20 g	10 g

To make up this energy deficit with corn, substitute an equivalent amount of dry matter, in this case 1 lb of corn for 6 lb of kikuyu. The amount needed to correct the deficiency would be $\frac{3.5 \text{ lb TDN}}{.81 \text{ (TDN of corn)} - 6 \text{ (.08 TDN of grass)} = .33}$ = 10.6 lb corn, replacing 10.6 × 6 = 64 lb kikuyu.

Recalculations must now be made to check the adequacy of the other nutrients.

	TDN	Protein	Calcium	Phosphorus
Mare's requirement	14.1 lb	3.0 lb	50 g	34 g
Intake from 69 lb kikuyu (133 - 64 = 69 lb)	5.5 lb	1.3 lb	16 g	13 g
Intake from 10.6 lb corn	8.6 lb	1.0 lb	1 g	16 g
Deficiency	none	.7 lb	33 g	5 g

There are still deficits of protein, calcium, and phosphorus. To correct the protein deficiency, substitute a protein supplement such as soybean meal for corn in the same manner that corn was substituted for kikuyu. Because soybean meal has about the same dry matter and energy as corn, an equal weight can be used:

$\frac{.7 \text{ lb protein needed}}{.458 \text{ protein of 1 lb soybean meal} - .09 \text{ protein of corn}}$ = 1.9 lb soybean meal. The daily ration for the mare now consists of 69 lb kikuyu grass (11.6 lb hay equivalent), 6.7 lb shelled corn, and 1.9 lb soybean meal.

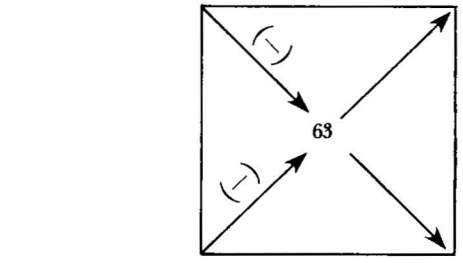
The missing phosphorus and calcium can be added to the feed by including dicalcium phosphate (19 percent phosphorus, or 86 g/lb, and 27 percent calcium, or 122 g/lb) at the rate of $\frac{5 \text{ g phosphorus needed}}{86 \text{ g/lb}}$ = 0.058 lb, or 26 g. This will supply the needed 5 g phosphorus and 7 of the 33 g calcium needed. For the remaining 26 g calcium, add limestone (34 percent calcium, or 154 g/lb): $\frac{26}{154}$ = 0.17 lb, or 76 g.

Perhaps an easier way to supply this mineral is by providing a free-choice mineral mix. Adding another compartment to the salt box for a general-purpose mineral mix will supply the most common calcium and phosphorus needs, including those of the lactating mare. It also may fill the trace-mineral need. Such a mix is listed in Appendix Table 3, and the suggested trace-mineral salt is given in Appendix Table 2. Common-range mineral supplements for cattle in Hawaii are not acceptable for horses due to their higher phosphorus levels (1:1 ratio of calcium and phosphorus). Ranchers who have used their cattle mineral supplements for horses find that mineral deficiencies have developed in their horses.

Example 3: Ration for a Horse at Medium Work on Hay and Corn

Assume an 1100-lb horse on pangola grass hay and corn. The first problem is to determine the hay allowance. Rules of thumb on hay usage range from 0.8 to 1.5 percent of body weight depending on the quality of hay (if high quality, use more hay), the energy level of grain (if grain has high energy, use more hay), and the amount and kind of work (if heavy work, reduce hay). After selecting the hay level to feed, proceed as in examples 1 and 2.

A more accurate method is to determine the level of energy desired and calculate the proportion and then the quantity of grain and hay, using feeds of choice. An energy level of 63 percent TDN for the total ration will generally keep the middle correct for normal riding. Table 1C shows that the 1100-lb horse doing medium work will eat 23 lb of feed daily. The following square method can be used to calculate the ratio of hay to concentrate. Draw a square. In the center of the square write the desired percentage of TDN in the feed (63 percent). Outside the upper left corner write the percentage of TDN in pangola hay (48 percent). Outside the lower left corner write the TDN percentage of corn (81 percent). Subtract diagonally across the square (smaller from the larger) and enter the results outside the corners on the right (63 - 48 = 15; 81 - 63 = 18).



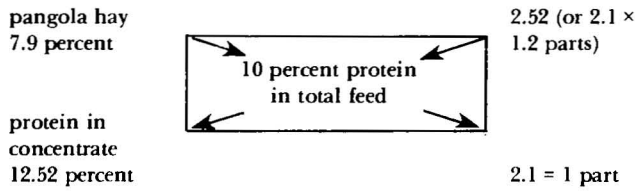
The horse will eat 23 lb/day. When calculated, this becomes 12.5 lb pangola hay and 10.5 lb concentrate to supply the animal's energy need. This ration should be checked for adequacy of protein, using the procedure given in the previous examples. In this case corn alone is used as the concentrate.

	Protein
Horse's requirement	2.3 lb
Intake from 12.5 lb pangola hay	1.0 lb
Intake from 10.5 lb corn	0.9 lb
Deficiency	0.4 lb

The ration needs 0.4 lb additional protein. The amount of soybean meal needed to supply this can be calculated by substituting soybean meal for corn: $\frac{0.4 \text{ protein need}}{.458 \text{ soybean meal} - .09 \text{ corn}} = \frac{0.4}{.368}$ = 1.1 lb soybean meal. The daily feed allowance now is 12.5 lb pangola hay, 9.4 lb corn, and 1.1 lb soybean meal.

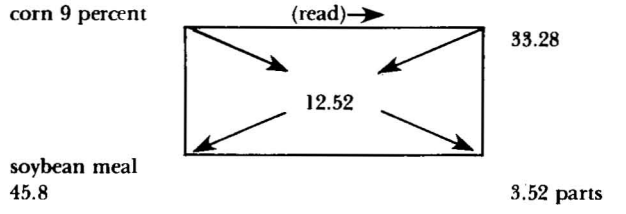
There is another way to calculate the percentage of protein needed in the total ration and in the concentrate mix of the horse in this example. According to Table 1C, he needs 23 lb of feed daily. The square method calculation showed that a mix of 18 parts hay and 15 parts concentrate (a ration of 1.2:1) will be needed to give a 63-percent TDN feed. Protein percentage needed in the total ration

is $100\left(\frac{\text{2.3 lb protein need}}{\text{23.0 lb total feed need}}\right)$, or 10 percent. The square may be used to calculate the percentage of protein needed in the concentrate.



The difference between the protein in the hay and the desired level (10 percent) needed in the total is 2.1 parts, which is equivalent to 1 part of the ration. Therefore, 2.1 × 1.2 parts, or 2.52, added to the 10 percent protein needed gives the 12.52 percent protein required in the concentrate.

The same square method can be used to determine the ratio of grain to protein supplement needed in order to attain a mix that is 12.52 percent protein.



The square can now be used to convert ratio to percentage for a total mix or for daily feeding each part of the concentrate separately.

This leaves vitamin A, calcium, and phosphorus to be supplied. The minerals are more easily fed free-choice except when a complete mixed feed is used. The vitamin A need is 12,500 IU daily, which can be added to the grain portion of the ration either as a mix or in daily allowances. Vitamin A may be purchased in premix form; in this way other vitamin needs can be taken care of at the same time. A satisfactory premix for this purpose is listed in Appendix Table 1. The horse would need 3.5 g, or about 1 tsp daily, of this mix, so one pound of the premix would be a 128-day supply.

When only a few horses are being fed, or when facilities for feeding are limited, it may be easier to mix a complete ration. A complete mixed feed also assures that a horse receives a balanced ration. Complete mixed feeds allow the addition of ingredients for special purposes, such as molasses for added palatability (and, in Hawaii, for reduced cost).

Example 4: Mixed Complete Ration for a Mature Horse

In making up a complete feed, try to produce a mix that will satisfy the needs of as many horses as possible without adding to the cost. It is clear from the nutrient requirement tables that mature horses, whether idle or working, must receive a mixture different than that required by growing horses or broodmares in production. If the same ration is used, the growing horse or broodmare needs additional supplements of protein, vitamins, calcium, and phosphorus.

The difference in need is sufficient to affect the cost of the ration and perhaps the performance of the work horse. For example, if a work horse is fed the broodmare's ration, the excess protein that has to be excreted adds to both the heat load of the horse and the cost of the ration. On the other hand, a working horse's need for proteins, vitamins, and minerals is not much different from that of an idle horse. A feed that is adequate for the idle horse (requiring the largest percentage of protein, vitamins, and minerals) can be used satisfactorily for any mature working horse so long as the added cost and extra heat load on the horse can be tolerated.

In formulating this complete mix, look up the horse's nutrient requirements, expressed in percentages of the ration. Then add those ingredients that are desired in known quantities and subtract what they supply from the total requirement. For example, in Hawaii molasses is a low-cost energy source that reduces dustiness of feed and adds palatability, but it should be limited to 10 percent because of its tendency to be laxative. Linseed meal is desirable because of its effect on hair coat, but with its high cost and low amino-acid lysine, it should not exceed 5 percent of the diet. Wheat mill run, available in Hawaii, is a low-cost feed that may replace oats as a bulky feed, though it probably should not be used in large quantities. Alfalfa contains many trace minerals, a high-quality protein, vitamins, and possibly some valuable unknown elements, but it is too expensive to use in large amounts.

FEEDING PRACTICES

Horse vary greatly in their likes, dislikes, and eating habits. Each horse needs individual attention to its needs; the art of feeding must accompany the science of feeding.

Avoid fads, fancies, and carefully leaked secret formulas with big price tags. Good green, leafy hay—free of weeds, dust, and molds—is the basis for a good feeding program, although a scientifically constructed diet without this ingredient, administered by a careful feeder, can be a good substitute.

It is important to feed horses regularly—2 to 3 times daily. Work quietly to avoid frightening the horses. Keep feed boxes and water troughs clean, serving only what the horse will eat in 30 to 40 minutes. Remove uneaten feed and reduce the amount next time. Make sure the horses' teeth are sound, and that they are able to chew their feed.

Look over the feeds as you fill the feed boxes, and discard any moldy or spoiled portions. Spread feed thinly for horses that eat too quickly, or put baseball-size smooth stones in their troughs. Watch for digestive disturbances and correct the feed as needed. Daily observation of droppings may help. Make any changes slowly, however, as abrupt changes in rations may throw horses off their feed. Keep water available, but don't allow them to drink too much just before or after heavy work, or after being deprived of water.

Vary the rate of development and conditioning of the horses to meet the needs of the owner, but avoid extreme overfeeding or underfeeding at all times. Bring highly conditioned horses down slowly by gradually reducing feed and exercise, but make sure all the horses get adequate exercise.

Because the nutrient requirements for horses vary greatly according to the class or function of the horse, no standard feeding operation can be both economical and adequate for all horses.

Orphan Foals

In order to survive, a colt needs the antibodies normally obtained from colostrum milk. If this is not available due to the absence of the mother, substitute a pint or more of horse blood-serum in the milk during the first 24 hours. Mare's milk contains less fat, protein, and total solids than cow's milk but more sugar. Cow's milk should be diluted by adding ¼ pt water to each pt of milk, along with 1 tsp sugar, when feeding the orphaned colt. During the first day, warm the milk to 100°F before feeding, and feed about every hour; gradually lengthen the feeding interval to 4 hours, and then feed 4 times daily. By 4 weeks a colt may be introduced gradually to whole cow's milk and fed 3 times daily. The daily feed should be increased according to need.

Growing Horses

A foal suckling a well-fed idle mare on good pasture may not need additional feed before weaning. If the mare is worked, or not fed properly, if the pasture is not good enough, or if one wishes to push the foal, it should be fed in a separate grain box away from the mare. Oats and rolled barley are excellent for young foals. If the dam gives little milk, or if a foal is being developed for show, 1 lb of commercial calf-starter supplement each day will be beneficial.

After weaning at 5 to 7 months, feed grain to foals at the rate of 1 lb grain per 100 lb body weight, along with good pasture or all the good hay they will eat. This will ensure good growth, but more grain may be fed to fit foals for show or sale. The best hay for young growing horses is alfalfa, clover, or a mixture of the two with grass hay. Mares that are not in foal may nurse their young for a longer time.

Some thoroughbred farms feed 1 to 2 gal whole cow's milk after the foals are weaned so that they may obtain all the early growth possible; this is seldom practical or economical on other horse farms.

A foal attains 55 to 60 percent of his growth the first year. Because a weanling can gain 1 lb his first winter on about half as much feed as is required the second winter, it is economical to feed well during that first winter. Young horses need a greater proportion of protein than do mature horses because they are growing muscle. They also need more mineral for bone growth.

Permit yearlings to graze, if possible. It is better for their health and much less expensive than stall care. The ration for a yearling is almost the same as for a weanling, but less protein is required. Two- and 3-year-olds require an even smaller proportion of protein and mineral.

Mature Horses

Mature horses need energy feeds for body maintenance and work. They may be maintained on pasture, hay, and even some straw. This method of feeding, however, does not keep the horse trim of middle and ready for instant, efficient use.

Here are some guidelines for determining either the amount of hay and grain needed for work horses or the total feed requirement if a complete 63-percent TDN mix is used:

(a) For horses with light activity maintenance plus needed exercise, or 1 to 3 hours per day of riding or driving, feed about 0.5 lb grain mix and 1.25 to 1.5 lb hay (or pasture equivalent) per 100 lb body weight, or 1.6 lb complete 63-percent TDN feed per cwt.

(b) For horses with medium activity (3 to 5 hours per day of riding or driving), feed about 1 lb grain mix and 1 to 1.25 lb hay (or some pasture equivalent) per 100 lb body weight, or 1.9 lb complete 63-percent TDN feed per cwt.

(c) For horses with considerable activity (5 to 8 hours per day of riding or driving), feed about 1.25 to 1.5 lb grain mix and about 1 lb hay (or some pasture equivalent) per 100 lb body weight, or 2.25 lb complete 63-percent TDN feed per cwt.

These recommended amounts are only guides. The actual amount of ration will vary with the response being obtained from the animal. Individual horses vary more in metabolic rate (hence, nutritional need) than other farm animals. Amounts will also depend on the condition of the horses as well as the growth rate and activity desired. For best results, horses should be kept in a thrifty condition, but should not be allowed to get too thin or too fat.

Show Horses

In order to properly fit a horse for show, start 4 to 6 months before the show. To place high the horse must, of course, have conformation. In addition, he must have the right combination of muscle and fat, as well as condition, bloom, true action, and alertness.

Assuming the horse has the necessary conformation, start with the basic ration 4 months before show time, and then gradually work him a little harder, slowly increasing his grain. The idea is to keep him hard or get him harder, and to make him gain weight while doing it. This doesn't require extra hard work—just a good brisk exercise or workout every day. As you gradually increase the grain, take away a little of the hay. Keep in mind, however, that this lowers the total protein of the ration; add soybean meal to keep the protein up. Some linseed meal may add luster to the coat. By show time all the excess belly will be off the horse. He will be hard enough that his muscles will stand out, yet he will be in good flesh.

After the show season is over, take 30 days to "let him down." Gradually decrease his grain—and his exercise, if desired—until he is back on his basic ration. When a horse is fitted for show and let down in this manner, there will be no harmful aftereffects. Conditioning a horse for racing requires a similar procedure, except that more vigorous training is required, and the horse should not be fat when he reaches his peak.

Broodmares

Good nutrition is essential to reproduction, but at breeding time and during the first two-thirds of pregnancy, it is unnecessary to increase the nutritional level of mares above that needed for light work. As indicated in Table 2B, protein should be increased to 10 percent of the ration during the last stage of pregnancy. The calcium and phosphorus should be almost doubled at this time. Condition of the mare is the best indication of whether the feed level should be increased or decreased. The mare should be in good flesh, but not too fat.

Lactation greatly increases the energy and protein requirements. A 1000-lb mare at peak lactation requires almost three times the usual protein and calcium, and more than twice the TDN and phosphorus normally required for maintenance. The total amount needed depends on the milk yield. It has been estimated that 0.027 lb digestible protein and 0.18 lb TDN are required for each pound of milk produced. The vitamin content of milk is also high. This high-level need during lactation makes a carefully balanced ration even more important at this time. If the mare is forced to supply the energy, protein, minerals, and vitamins from her body reserves, milk production will be depressed, and her usefulness and appearance will long be impaired.

NUTRITIONAL DISEASES OF HORSES
(Walker and Miller, 1967)

Azoturia (Monday Morning Sickness)

Symptoms: Excessive sweating; nervousness; abdominal distress; stiff gait; reluctance to move; coffee-colored urine; excess urea or other nitrogen compounds in the urine.

Cause: The true cause of Azoturia is not known. Characteristically it occurs in horses (on high grain rations) that have rested 1 or 2 days without feed reduction, and then have returned to work. There is evidence that selenium or tocopherol might be involved.

Prevention: Reduce feed when horses are idle. Exercise daily or turn in pasture.

Treatment: Call a veterinarian (urgent).

Colic

Symptoms: Acute abdominal pain; profuse sweating; distended abdomen; violent kicking and rolling.

Cause: Improper management, feeding, watering, working, or parasitism.

Prevention: Proper feeding, watering, and working.

Treatment: Call a veterinarian. Keep animal moving until help arrives.

Heaves

Symptoms: Nostrils dilated; coughing and difficulty in breathing; rapid inspiration and forced expiration with heave line along rib border.

Cause: Essential cause unknown; damaged or moldy feed usually incriminated; excessive intestinal fermentation. Often follows respiratory disease such as distemper or pneumonia.

Prevention: Provide good, clean, dust-free feed; provide complete pelleted feed; provide moisture on feed.

Treatment: Mild cases progress to severe cases and always should be regarded as serious. Coughing aggravates problem, so control the cough with medication. Call a veterinarian. Follow prevention procedures.

Laminitis (Founder)

Symptoms: Lameness, particularly in forefeet. Condition may be acute or chronic. Acute cases are visibly sick and show colic, perspiration, reluctance to move; hoof is hot to touch. Chronic cases show deep vertical cracks in hoof and heavy horizontal ridging; hoof is very dry and brittle.

Cause: Injury to blood supply to hoof. May be caused by overloading the stomach with grain, lush pasture, or water; poor husbandry practices.

Prevention: Provide adequate ration and observe good husbandry practices.

Treatment: Call a veterinarian. Apply ice packs to the feet or have the animal stand in cold water as a helpful first-aid measure. Acute cases require urgent attention.

Moonblindness (Periodic Ophthalmia)

Symptoms: Hazy vision in one or both eyes, which may affect animals intermittently.

Cause: Evidence points to lack of riboflavin in the diet. Microorganisms also have been indicated.

Prevention: Provide a ration that contains at least 40 mg riboflavin per day. Green grass and green, leafy hay are excellent sources.

Treatment: Call a veterinarian. Follow prevention procedure.

Rickets

Symptoms: Enlargement of the ends of the long bones, particularly around hock and knee joints. Animals may show pain when moving about.

Cause: Imbalance of calcium, phosphorus, and vitamin D.

Prevention: Supply the correct ratio of these three important nutrients.

Treatment: Follow prevention procedure. If disease is too far advanced, animal may not recover fully.

Urinary Calculi (Water Belly)

Symptoms: Frequent attempts to urinate; dribbling or stoppage of the urine. Urine is frequently blood-tinged. Usually only males are affected.

Cause: Not completely understood. Improper calcium:phosphorus ratio and high potassium intake appear to increase incidence; lack of salt.

Prevention: Incidence appears to be reduced by proper calcium:phosphorus ratio and inclusion of 1 to 3 percent salt in the concentrate ration.

Treatment: Call a veterinarian. Also follow prevention procedure.

LITERATURE CITED

National Academy of Sciences, Subcommittee on Horse Nutrition. 1978. Nutrient requirements of horses. 4th revised ed. No. 6. Washington, D.C.

Walker, Garth L., and M. Wayne Miller. 1967. Horse nutrition. 27th Semi-Annual Management Nutrition Council, American Feed Manufacturers Assn. pp. 10–14.

APPENDIX

Appendix Table 1. A vitamin mix designed for chicken breeder diets that is satisfactory for a horse ration.

Vitamin	Amount per lb of premix
Vitamin A	1,600,000 IU
Vitamin D_3	400,000 IU
Vitamin E	1,500 IU
Thiamine (B_1)	200 mg
Riboflavin (B_2 or G)	800 mg
d-Pantothenic acid	1,472 mg
Niacin	6,000 mg
Choline chloride	80,000 mg
Vitamin B_{12}	2 mg
Folic acid[a]	60 mg
Menadione sod. bisulfite (K)[a]	400 mg
B.H.T.	22 g

[a]Probably not needed as additive.

Appendix Table 2. Trace mineral salt for use in mineral mix.

Mineral	Percentage	g/kg
Salt (NaCl)	95.970	950–970
Zinc (Zn)	0.400	4.00
Magnesium (Mg)	0.150	1.50
Copper (Cu)	0.100	1.00
Cobalt (Co)	0.012	0.12
Iodine (I)	0.007	0.07

Appendix Table 3. Mineral mix for self-feeding horses in addition to salt.

Ingredient (%)	Feed contains roughage only	Feed contains concentrates
Trace mineral salt	25	25
Limestone	25	50
Dicalcium phosphate	50	25

Appendix Table 4. Sample rations (percentage composition).

Ingredient	Mature horse		Weanling		Broodmare (late pregnancy & lactation)	
	Complete	Concentrate	Complete	Concentrate	Complete	Concentrate
1) *Guinea grass hay base of medium to low quality*						
Gr. hay	27.0	—	24.2	—	26.0	—
Alfalfa meal	5.0	6.8	5.0	6.8	5.0	6.8
Molasses	10.0	13.7	10.0	13.7	10.0	13.7
Wheat mill run	10.0	13.7	10.0	13.7	10.0	13.7
Corn	40.6	55.7	32.8	43.3	33.6	44.7
Linseed meal	5.0	6.8	—	—	—	—
Soybean meal	1.9	2.6	16.4	22.5	14.6	20.0
Limestone	0.5	0.7	1.1	1.5	0.5	0.7
Dicalcium phosphate	—	—	0.5	0.7	0.3	0.4
Vitamin mix	0.1	0.1	0.1	0.1	0.15	0.15
Composition of ration						
TDN (%)	63.0	73.3	63.0	73.5	63.0	72.7
Kcal/g DE[a]	2.73	3.22	2.73	3.23	2.73	3.20
Protein (%)	10.0	12.2	14.0	17.7	13.4	16.8
Calcium (%)	0.43	0.38	0.79	0.96	0.50	0.55
Phosphorus (%)	0.36	0.36	0.51	0.58	0.46	0.50
2) *Panicum grass hay base of high quality*						
Panicum hay	37.0	—	34.0	—	34.0	—
Pineapple bran	20.0	31.6	20.0	30.8	20.0	30.3
Wheat mill run	10.0	16.0	10.0	15.4	10.0	15.2
Molasses	10.0	16.0	10.0	15.4	10.0	15.2
Corn	16.3	26.0	8.3	12.8	11.1	16.6
Linseed meal	5.0	7.9	—	—	—	—
Soybean meal	1.3	2.0	16.3	25.0	14.3	21.7
Dicalcium phosphate	—	—	1.0	0.8	—	—
Limestone	0.3	0.5	0.3	0.5	0.5	0.8
Vitamin mix	0.1	0.15	0.1	0.15	0.15	0.22
Composition of ration						
TDN (%)	63.0	69.5	63.0	70.8	63.0	70.0
Kcal/g DE[a]	2.73	2.79	2.73	3.06	2.73	3.03
Protein	10.0	10.3	14.0	16.5	13.5	15.4
Calcium	0.47	0.40	0.74	0.44	0.53	0.50
Phosphorus	0.38	0.38	60.0	0.38	0.40	0.39
3) *Bagasse pith base*						
Sugarcane bagasse[b]	29.5	—	28.7	—	29.4	—
Alfalfa meal	5.0	—	5.0	—	5.0	—
Molasses	10.0	—	10.0	—	10.0	—
Wheat mill run	10.0	—	10.0	—	10.0	—
Corn	35.0	—	25.0	—	26.8	—
Linseed meal	5.0	—	—	—	—	—
Soybean meal	4.8	—	19.8	—	17.8	—
Limestone	0.6	—	0.6	—	0.3	—
Dicalcium phosphate	—	—	0.8	—	0.7	—
Vitamin mix	0.1	—	0.1	—	1.5	—
Composition of ration						
TDN (%)	63.0	—	63.0	—	63.0	—
Kcal/g DE[a]	2.73	—	2.73	—	2.73	—
Protein	10.0	—	14.0	—	13.5	—
Calcium	0.41	—	0.66	—	0.51	—
Phosphorus	0.31	—	0.47	—	0.40	—

[a]Digestible energy.

[b]Bagasse pith should be dried thoroughly at the time of production in order to prevent mold, which is dangerous to horses.

DISCLAIMER

Reference to a company or product name does not imply approval or recommendation of the product by the College of Tropical Agriculture and Human Resources, University of Hawaii, or the United States Department of Agriculture to the exclusion of others that may be suitable.

Hawaii residents may order **single copies** of this publication free of charge from county offices. **Out-of-State inquiries** or **bulk orders** should be sent to the Agricultural Publications and Information Office, College of Tropical Agriculture and Human Resources, University of Hawaii, 2500 Dole Street, Krauss Hall 107, Honolulu, Hawaii 96822. Price per copy to bulk users, $.65 plus postage.

NOTE: As part of a structural reorganization, the Hawaii Agricultural Experiment Station and the Hawaii Cooperative Extension Service have been merged administratively under the name HAWAII INSTITUTE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Noel P. Kefford, Director of the Institute and Acting Dean of the College, Cooperative Extension Service, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Honolulu, Hawaii 96822. An Equal Opportunity Employer providing programs and services to the citizens of Hawaii without regard to race, color, national origin, or sex.

CIRCULAR 498–12/81 (2.5M)